UNIVERSITAT POLITÈCNICA DE CATALUNYA
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BEKASI-EAST JAKARTA AIRPORT
GROUND SIDE

Report

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1.1 Aviation context in Indonesia

Indonesia is the fourth most populated country in the world and the largest economy in south-east Asia. Indonesia is also, a growing touristic destination because its outstanding nature marvels and cultural monuments. It's topography which is composed by many island makes essential the domestic air transport.

Jakarta (located at the island of Java) is the centre of government, commerce and industry of Indonesia. Currently Jakarta has an international airport (Soekarno-Hatta International Airport). It operates around the 250% over its design capacity and an interesting fact is that last year 40% of its flights were delayed. Efforts have been made to decrease this problem opening a small military airport for civilian domestic flights. Nevertheless, the problem still persists.

The current Jakarta airport cannot be expanded, due to nearby neighbourhoods. "Some news have been recently published by Jakarta authorities confirming the urge of a new airport around Jakarta to absorb the saturated traffic of the Soekarno-Hatta International Airport, even after constructing a new runway and terminal on it.

All in all, it is essential to construct a new airport. Moreover, the secondary airport, really small, is only focused on military and private services and does not have enough fields at its surroundings to expand, as Jakarta air traffic requires.

Therefore, the need for a new commercial airport near Jakarta is clear. Coming up next, a project for this new airport will be developed.

1.1.1 Airport location

The main idea to find a good location was to put the new Jakarta airport in an area not too far from the city with enough space to build a big airport which has opportunities to expand in a further future.

Following this parameters, the location chosen geographically is situated to the east of the city of Jakarta at 32 km from the city center. It is also located above the emerging city of Bekasi that in the last years is increasing its industry hosting several multinationals. In addition, the terrain is not edified yet and extensive, plus it is non-mountainous and obstacles-free.

Figure 1.1.1: Bekasi-East Jakarta Airport selected location.

It is a huge free obstacle flat field, without relevant slope gradients and the terrain is not edified yet. It is an exceptional location due to its huge amount of terrain available where companies could settle down taking advantage of the airport proximity, low terrain costs and direct connection with the down town. There is enough space to become also a logistic distribution centre of the island and Indonesia.

Finally, as it is an almost virgin land, communication is limited. Therefore, the solution is easy. The present Jakarta motorway will be extended. As it is shown on Fig. 1.1.1 indicated with a discontinuous line, there will be two connections between the current and the new highway.

Connection between airports will be achieved thanks to this new built highway. It will take 40min from door to door. Connection network of free-busses between both airports will make transfers safe and easy. There will be also available buses to and from the city centre, at low prices. During rush hours, a specific way will be delimited only for airport bus transfers.

1.1.2 Current traffic

The starting point has been Soekarno-Hatta Airport. As it can be seen on fig.1.1.2, currently Soekarno-Hatta Airport is handling volumes of passengers around 50 million passengers by year and its growth is about 5 million passenger per year.

The little passenger decrement over the 2014 and 2015 was due some serious floods that affected de Java island, during specially strong typhoons on the raining season.

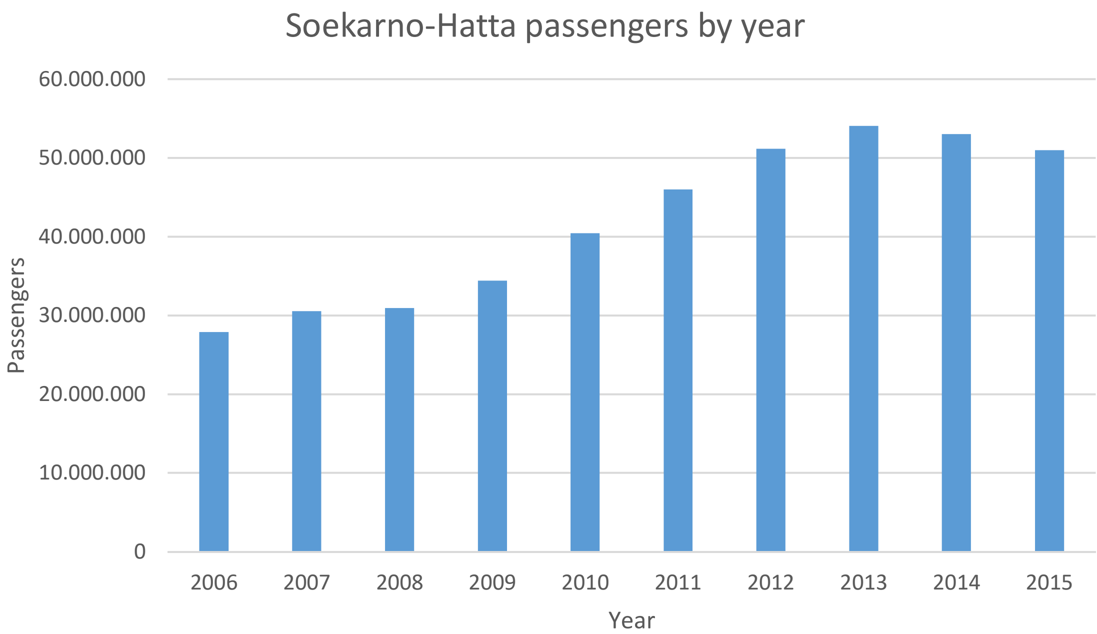


Figure 1.1.2: Soekarno-Hatta International Airport passengers by years

Monthly arrivals to Jakarta are represented on Fig. 1.1.3. On the one hand, from this figure is seen that as it was stated on the previous one, Fig. 1.1.2, volume of passengers grow every year, except the two past ones because nature inclemencies. On the other hand, monthly passengers distribution is pretty much equal every year with two well identified growth. The first one is during the summer months, June, July and August. Jakarta is a well known tourist country. The second, growth is really specific, is located on the last days of December, coinciding with the Christmas holidays. A lot of tourist visit this tropical country because Christmas here is so much different from the cold sites.

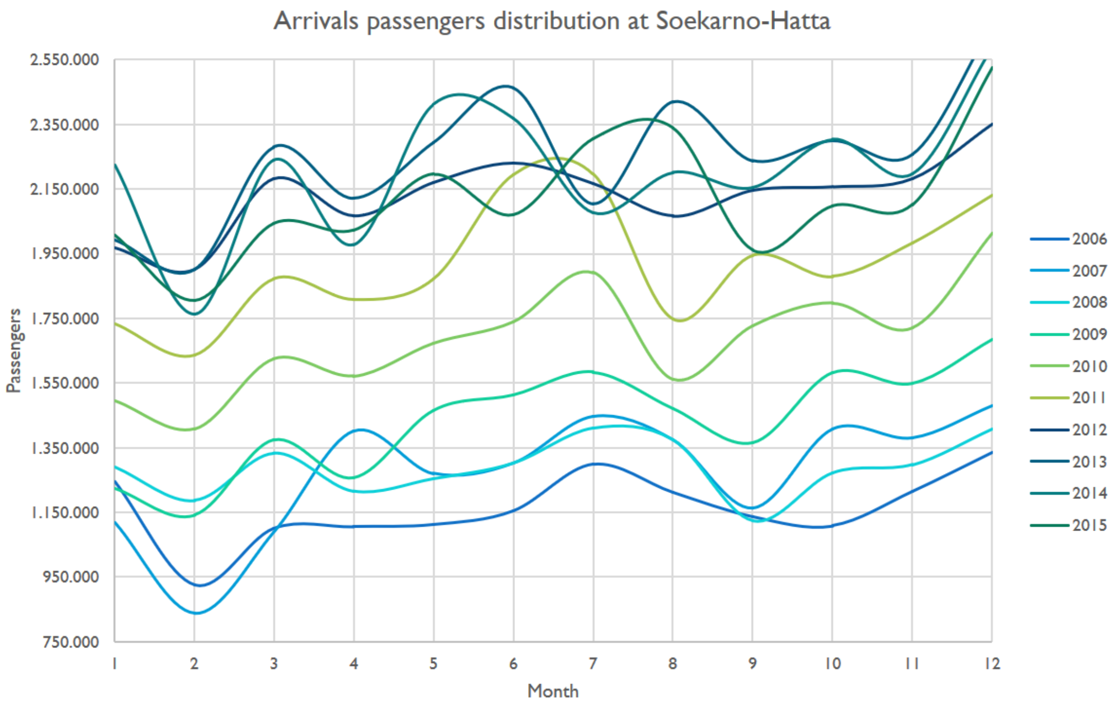


Figure 1.1.3: Soekarno-Hatta International Airport passengers by months

Soekarno-Hatta domestic (Fig. 1.1.4) and international (Fig. 1.1.5) operations distribution along the day on a mean day have the following pattern:

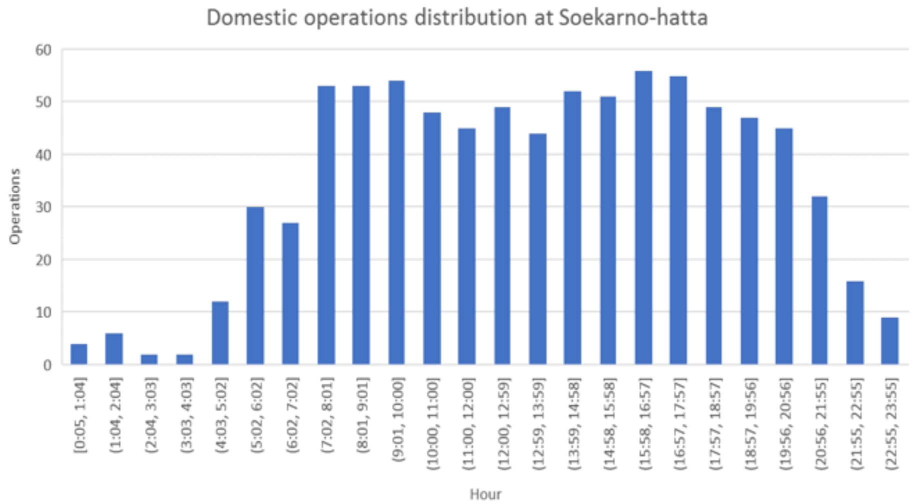


Figure 1.1.4: Soekarno-Hatta International Airport domestic flights distribution on busy day.

From Fig. 1.1.4 some conclusions can be extracted. Firstly, despite the airport is open all the year, 7 days a week, 24 hours. Commercial flights are concentrated between 07:00 AM and 10:00 PM, so, the airport is commercially active around 15h for day. Secondly, the two summits on the graph, suggest that airlines have two based planes on the airport for the short domestic flights. Finally,it is interesting to see how valleys between summits are full with arrivals, indicating that the airport is working with high volumes of operations.

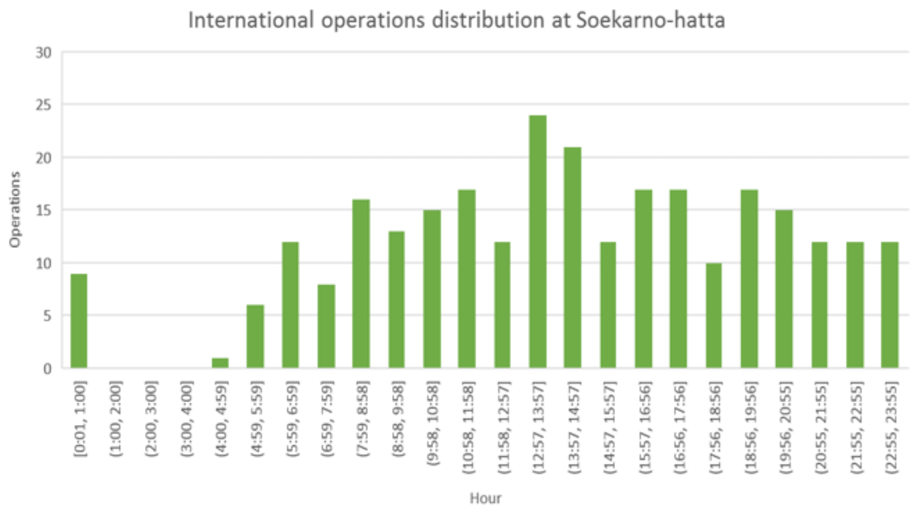


Figure 1.1.5: Soekarno-Hatta International Airport international flights distribution on busy day.

From Fig. 1.1.5, International operations show a clear summit at 01:00 PM, what leads us to think that airlines have one principal international plane based on the airport.

1.1.3 Occupation factor

It is being estimated from the **International Air Transport Association** (IATA) reports. The occupation factor will be 77%.

The previous value is being obtained seeing the historical Passengers Load Factors over Asia on the report [3]. Note that Passengers Load Factor refers to the Occupation factor. Also, a low [2] and high [1] passenger movements months reports, had been used to estimate this factor on flights over Asia Pacific sea islands.

Finally, from the last report on passengers

1.2 Reference aircraft

The new airport will have two runway with different Airfield reference keys. The International flights thought one, with 4E reference key and the domestic dedicated runway with 4C reference key.

New airport, will absorb around de 40% of Soekarno-Hatta International Airport air traffic.

As it can be seen, the most common code letter is C, but some big planes with code E can also appear. That is why, the new aircraft, despite it will be dedicated domestic flights, will be able to handle big international flights also, Fig. 1.2.1.

	Code letter				
Operation	A	B	C	D	E
Domestic	0%	7%	71%	2%	0%
International	0%	0%	2%	8%	10%
TOTAL	0%	7%	73%	10%	10%

Figure 1.2.1: Soekarno-Hatta International Airport aircraft class distribution.

1.2.1 Aircraft type for 4E reference key airfield

A380 is discarded, because the new airport aims to absorb domestic flights mainly but also some international traffic (close range). B777-300 and A330-300, are found to be the bigger planes with higher requirements to operate on the new airport.

1.2.2 Aircraft type for 4C reference key airfield

B737-800, is chosen because have longer take-off requirements compared to A320 and other smalls planes, operating

1.2.3 Conclusions

1.3 Forecast computation

In order to do a realistic study for the new Bekasi-East airport traffic, it is previously established the Soekarno-Hatta International Airport (CGK) as the reference airport for future operations prevision. According to one of the IATA main recommended methods for the elaboration of traffic previsions, data from historical series of CGK traffic has been used so as to be able to extrapolate the study horizons of the airport to be designed.

In order to do this, it is necessary to calculate the annual variation tendency of the different traffic parameters from historical data of the last years. Data mentioned is extracted from the "Directorate General of Civil Aviation" (DGCA) and "FlightRadar24" web pages.

With this information, the next step is to calculate the values of horizon scenario, which has been fixed in 15 years with respect to the airport inauguration (it is expected to be finished in

2020). The horizon scenario will be fixed then in 2035.

Before starting the study of passenger and operation demands, some important aspects will be taken into account:

- The airport to be projected will absorb nearly the 40% of CGK's current traffic, which corresponds to the percentage of delayed flights due to congestion.
- The growth tendencies, concretely the Compound Annual Growth Rate (CAGR), has been calculated using the data corresponding to the five more recent years. The expression used to calculate the values is the following one:

$$CAGR = \left(\frac{V_{fin}}{V_{ini}}\right)^{\frac{1}{t_{fin}-t_{ini}}} - 1 \tag{1.3.1}$$

- The prediction of passengers and operations have been calculated using three possible scenario.
  - Neutral scenario: The growth is constant along time. This neutral scenario has been used to estimate the number of passengers and operations in 2035.
  - Optimistic scenario: The growth is constant along time but in 2025 is multiplied by a factor of 1,5 due to, for example, a boom of tourism in the city.
  - Pessimistic scenario: The growth is constant along time but in 2025 is divided by a factor of 2 due to, for example, a period of time with adverse atmospheric phenomena.

In addition, both the airlines as well as the percentage of operations absorbed from CGK are detailed in the following table:

AIRLINES	% OPERATIONS
Garuda	31.62
Citilink	7.11
Emirates	0.35
Etihad	0.44
Qatar	0.53
Total	40.05

Table 1.3.1: Airlines absorbed and operation percentages from CGK.

1.3.1 Passenger prediction

In this section it will be calculated the number of annual passenger both domestic and international in the horizon scenario in 2035.

Taking into account the historical passenger data collected from CGK airport, one can obtain:

Year	Domestic PAX	International PAX	Total PAX
2011	35.412.018	10.589.310	46.001.328
2012	39.499.760	11.674.136	51.173.896
2013	41.318.616	12.743.330	54.061.946
2014	40.531.384	12.489.680	53.021.064
2015	38.262.800	12.696.766	50.959.566

Table 1.3.2: Volume of passengers of the last 5 years in CGK Airport.

The CAGR's calculated from data in the table above:

- CAGR for Neutral Scenario

Type	Initial Value	Final Value	PAX CAGR
Domestic	35.412.018	38.262.800	1,95%
International	10.589.310	12.696.766	4,64%

Table 1.3.3: Neutral scenario passenger CAGR.

- CAGR for Optimistic and Pessimistic Scenario (applied from 2025)

Type	Optimistic PAX CAGR	Pessimistic PAX CAGR
Domestic	2,93%	0,98%
International	6,96%	2,32%

Table 1.3.4: Optimistic and pessimistic scenario passenger CAGR.

Using the growth taxes computed previously, it is obtained the following results in horizon scenario.

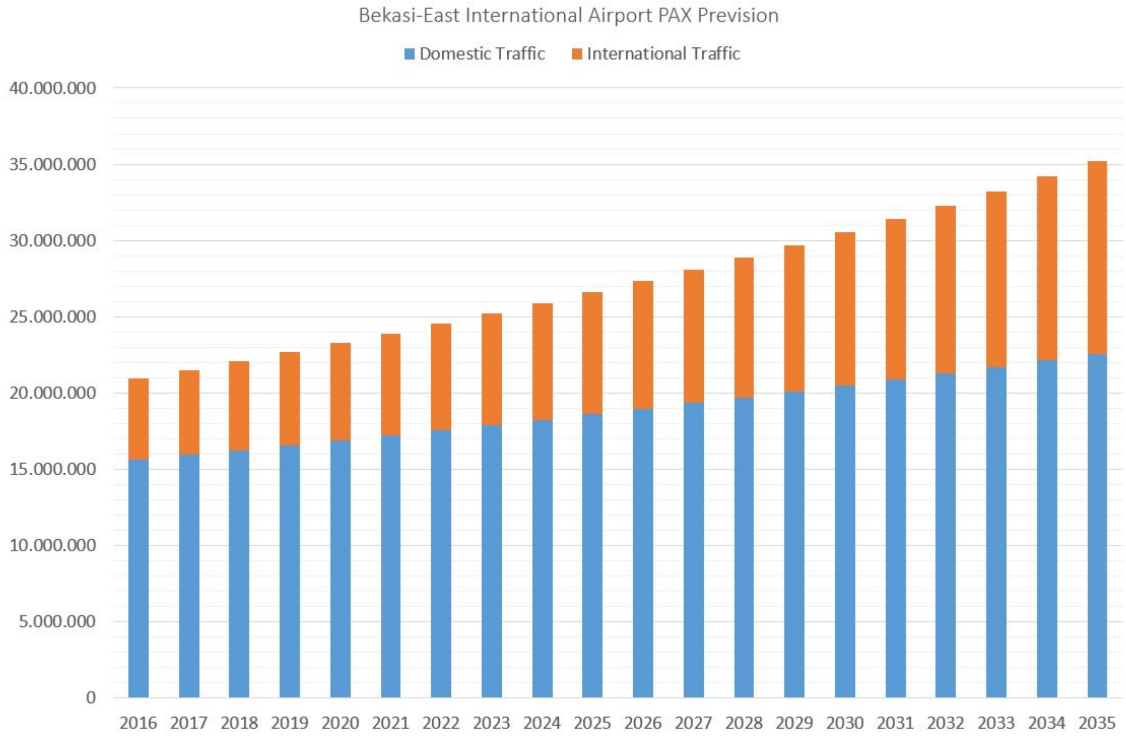


Figure 1.3.1: Bekasi-East Jakarta Airport passenger prevision.

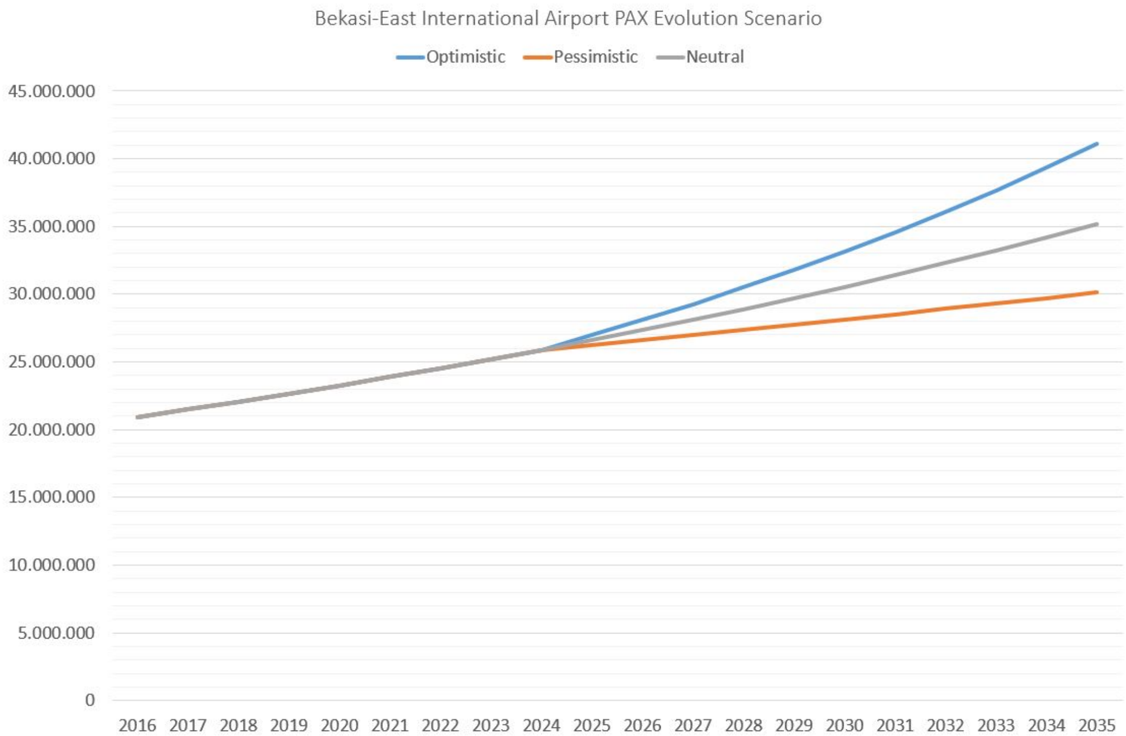


Figure 1.3.2: Bekasi-East Jakarta Airport passenger prevision for neutral, optimistic and pessimistic scenario.

1.3.2 Operations prediction

In this section it will be calculated the number of annual operations both domestic and international in the horizon scenario in 2035.

Taking into account the historical operations data collected from CGK airport, one can obtain:

Year	Domestic OPS	International OPS	Total OPS
2011	279.668	68.241	347.909
2012	327.416	79.288	406.704
2013	329.568	82.924	412.492
2014	331.120	115.184	446.304
2015	301.696	84.919	386.615

Table 1.3.5: Volume of operations of the last 5 years in CGK Airport.

The CAGR's calculated from data in the table above:

- CAGR for Neutral Scenario

Type	Initial Value	Final Value	OPS CAGR
Domestic	279.668	301.696	1,91%
International	68.241	84.919	5,62%

Table 1.3.6: Neutral scenario operations CAGR.

- CAGR for Optimistic and Pessimistic Scenario (applied from 2025)

Type	Optimistic OPS CAGR	Pessimistic OPS CAGR
Domestic	2,87%	0,96%
International	8,43%	2,81%

Table 1.3.7: Optimistic and pessimistic scenario operations CAGR.

Using the growth taxes computed previously, it is obtained the following results in horizon scenario.

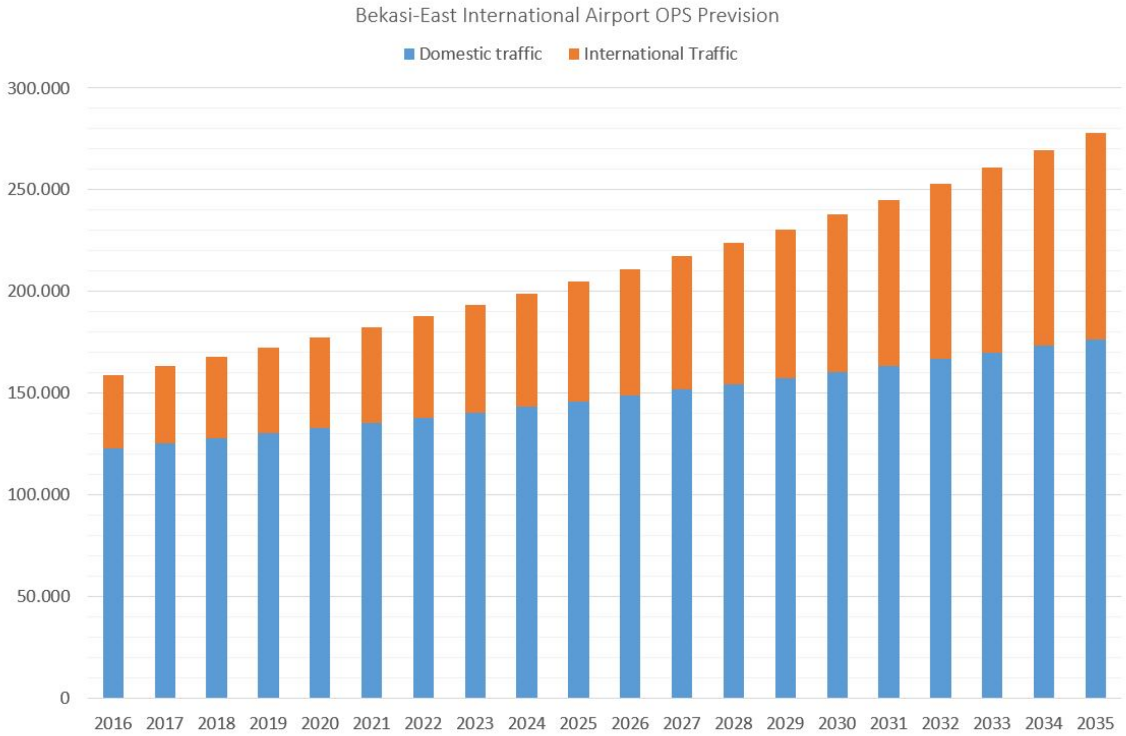


Figure 1.3.3: Bekasi-East Jakarta Airport operations prevision.

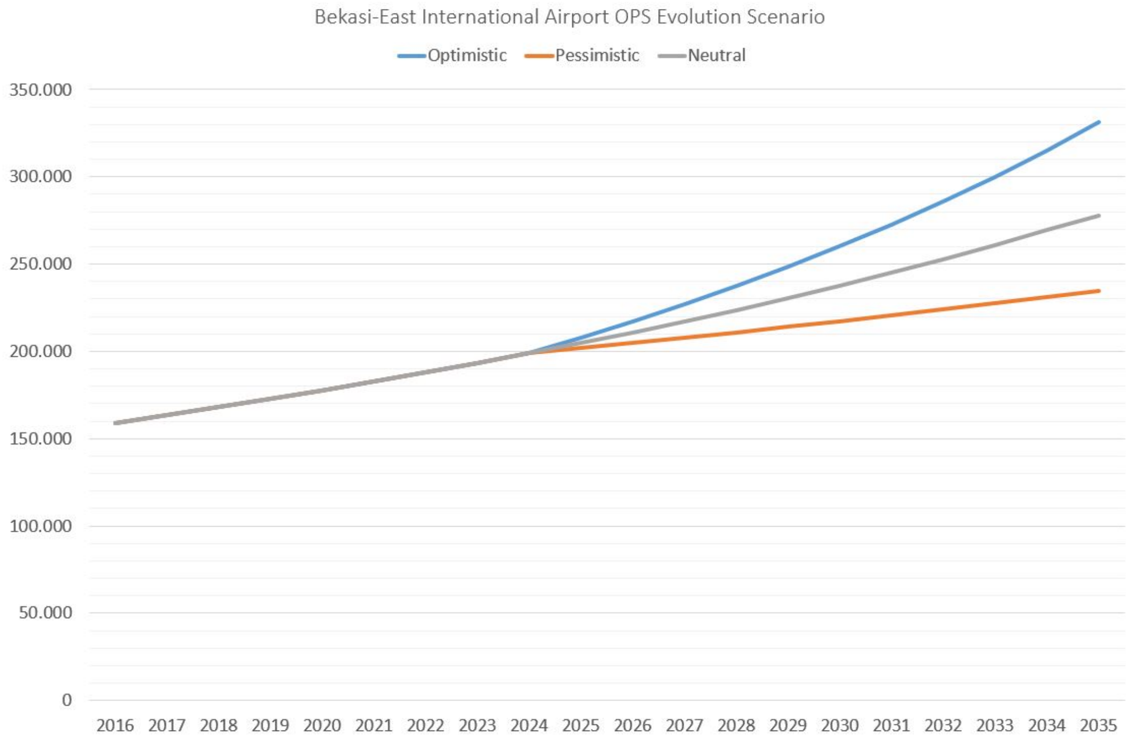


Figure 1.3.4: Bekasi-East Jakarta Airport operations prevision for neutral, optimistic and pessimistic scenario.

1.3.3 Flights on busy day

The total number of passenger and operations calculated for the horizon scenario in 2035 are:

Traffic in 2035	
Passenger	35.170.379
Operations	278.011

Table 1.3.8: Traffic of Bekasi-East Jakarta Airport in 2035.

IATA defines the busy day as the second busiest day in an average week during the peak month. An average weekly pattern of passenger traffic is calculated for that month. Peaks associated with special events such as religious festivals, trade fairs and conventions, and sport events, are excluded.

Having 2015 busy month values of passenger and operations for CGK airport and the total year values, the percentage of peak above mean can be calculated. Supposing this percentage above mean is conserved along time, it is easy to extrapolate the number of passenger and operations in busy day for the new Bekasi-East Airport. The following results are obtained:

Bekasi-East Jakarta Airport PAX in 2035			
Type	Domestic	International	Total
Total Year	2.233.960	1.253.000	3.486.960
Mean Month	22.568.860	12.601.519	35.170.379
Mean Day	1.880.738	1.050.127	2.930.865
Busy Day	73.778	41.009	114.787

Table 1.3.9: Determination of number of passengers in busy day.

Bekasi-East Jakarta Airport OPS in 2035			
Type	Domestic	International	Total
Total Year	176.525	101.486	278.011
Mean Month	14.710	8.457	23.168
Mean Day	484	278	762
Mean Hour	24	14	38
Max Hour	30	20	50

Table 1.3.10: Determination of maximum number of operations per hour.

With the number of maximum hourly operations and an utilisation factor of 77% for both domestic and international flights, the number of maximum passenger per hour in the airport is calculated.

Bekasi-East Jakarta Airport Peak Hour			
Type	Domestic	International	All
Utilisation Factor	77%	77%	-
Max PAX/OPS	189	189	-
PAX/OPS	146	146	-
Max PAX/H	4.394	2.870	7.264

Table 1.3.11: Determination of the peak hour passenger value.

2 | Terminal building distribution

2.1 Surface distribution

The terminal building interiors will be distributed according to the FAA criteria. This method has been chosen because it differentiates between domestic and international passenger flows, which are very well defined at this airport.

In order to manage and distribute the space available, the forecasted traffic predicted in the prognosis is to be used.

In first place, as shown in table **??**, the surface corresponding to domestic traffic is distributed. According to prognosis data, the number of domestic passengers at design hour will be of 4850.

Surface	% out of total	m2/pax	m2 total
Departures	0.0435	0.609	2953.65
Arrivals	0.0435	0.609	2953.65
Waiting lobby	0.0739	1.035	5019.75
Restrooms	0.013	0.183	887.55
Kitchens	0.0652	0.913	4428.05
Restaurants	0.0652	0.913	4428.05
Offices	0.1957	2.739	13284.15
Other	0.0217	0.304	1474.4
Circulation	0.4783	6.696	32475.6
TOTAL			**67904.85**

Table 2.1.1: Estimated surfaces according to FAA (domestic flights).

In second place, as shown in table **??**, the surface corresponding to international traffic is distributed. According to prognosis data, the number of international passenger at design hour will be of 3168.

Nevertheless, due to our airport structure and preliminary design, some of these areas are

Surface	% out of total	m2/pax	m2 total
Departures	0.0435	0.609	2953.65
Arrivals	0.0435	0.609	2953.65
Waiting lobby	0.0739	1.035	5019.75
Restrooms	0.013	0.183	887.55
Kitchens	0.0652	0.913	4428.05
Offices	0.1957	2.739	13284.15
Other	0.0217	0.304	1474.4
General circulation	0.307	6.145	19467.36
Immigration	0.042	0.838	2654.78
Customs	0.084	1.676	5309.57
Health	0.028	0.559	1770.91
Other checkpoints	0.006	0.112	354.816
Circulation	0.198	3.966	12564.28
TOTAL			**63363.17**

Table 2.1.2: Estimated surfaces according to FAA (international flights).

going to be shared between domestic and international passengers. This will allow to tighten the space and reduce the extension of the terminal building, which will be too extense for the number of passengers at design hour.

Therefore, the final dimensioning of the airport will be as follows, shown in table **??**:

General (shared)	m2	Domestic	m2	International	m2
Departures	4725.56	**Waiting lobby**	5019.75	**Immigration**	2654.78
Arrivals	4724.56	**Circulation**	32475.6	**Customs**	5309.57
Restaurants	7082.83			**Health**	1770.91
Offices	21248.50			**Other checkpoints**	354.81
Other	2358.27			**Circulation**	12562.3
Restrooms	1419.77			**General circulation**	19456.36
Kitchens	7082.83			**Waiting lobby**	3009.60
TOTAL	**48641.34**		**37495.35**		**45131.33**

Table 2.1.3: Total surface distribution of terminal building.

The total surface of the terminal building area, dedicated to passengers and airport management is of 131267 m^2.

2.2 Dimensioning of elements

1. **Check-in counters:** in order to define the check-in area, we have to determine the queueing area and the counters area. Considering the following parameters:

PHP(dep)	2000	50% for arrivals and departures
b	0	Connecting pax not processed in airside
y	20 min	Average ocuppation time
s	1.9 m^2	Recommended space by pax
o	1.5	Number of visitors for each pax
t	120 s	Average time of processed pax

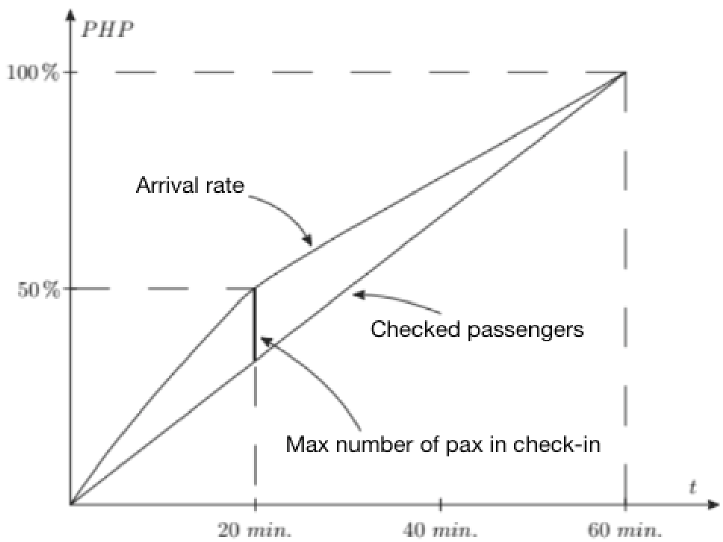


Figure 2.2.1: Plot PHP – time.

Looking at the figure, it can be seen that the maximum number of checked-in passengers is 50% in the first 20 min. Therefore:

$$\text{Fraction of total PHP} = \frac{PHP}{2} - \frac{PHP}{3} = \frac{PHP}{6}$$

Therefore, the queueing area is of:

$$\textbf{Queueing area} = 1.1\left(\frac{PHP+b}{6}s\right) \approx 700\mathrm{m}^2 = 750\mathrm{m}^2$$

Accounting for a security margin: Queueing area $= 750\mathrm{m}^2$.

The number of check-in counters must consider:

- Traffic characterized as international long-haul.

- The average passenger load in the hour before and after the peak hour is 70% of PHP.
- Maximum queueing time (MQT) is 10 minutes.
- Average time of check-in procedure (PTCi) is of 120 seconds.

We can compute the following factor:

$$X = \text{30-min peak at check-in} = PHP \cdot F1 \cdot F2 = 2000 \cdot 0.3 \cdot 1.35 = 810$$

Obtaining $F1$ and $F2$ factors from IATA tables:

Number of flights during the peak hour period	Domestic/Schengen/ Short-haul International	Long-Haul International
1	39%	29%
2	36%	28%
3	33%	26%
4 or more	30%	25%

Figure 2.2.2: F1: 30-min peak at check in as % of PHP.

Average passenger load in the hour before and after the peak hour period in % of the PHP	Domestic	Schengen/Short-haul International	Long-haul International
90%	1.37	1.43	1.62
80%	1.31	1.40	1.54
70%	1.26	1.35	1.47
60%	1.22	1.30	1.40
50%	1.18	1.25	1.33
40%	1.14	1.20	1.26
30%	1.11	1.15	1.19
20%	1.07	1.10	1.12
10%	1.03	1.06	1.06

Figure 2.2.3: F2: Additional demand based on previous and following flights to peak hour.

- MQT = 10 min (Maximum Queueing Time)
- X = 810 (30-min peak at check in)

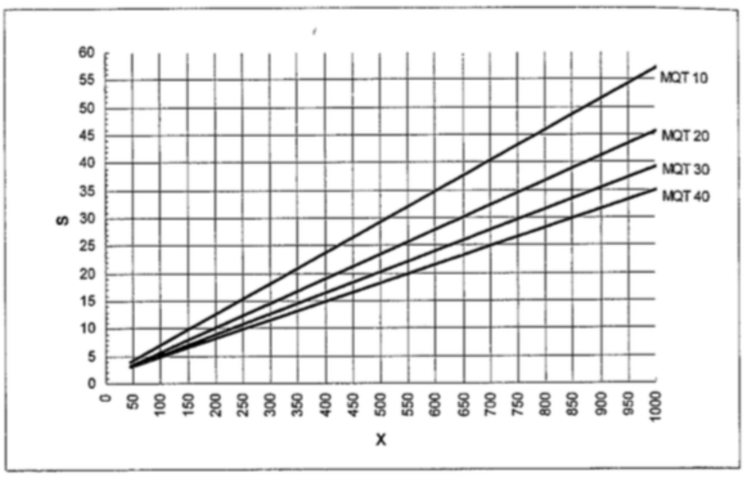


Figure 2.2.4: Plot: S-X-MQT.

We can determine S as 49 check-in counters. Also we can add a 20% for business class check-in counters.

$$\boxed{\textbf{Total number of check-in counters} = 59 \text{ counters}}$$

2. **Total passport control positions**: A multiple queue system will be used, having two accesses on each side, to reduce queues and passenger walking distances.

   Considering:

   - PHP(tot) $= 4000$ pax.
   - $b = 0$ $\rightarrow$ connecting pax not processed in airside.
   - $t = 27\,\text{s} = 0.45\,\text{min}$ $\rightarrow$ average time per passenger in the process.

$$\boxed{\textbf{Positions number} = 1.1\frac{PHP + b}{60}\Delta t = 30}$$

   The total number of passport control positions will be 18. Since the ratio arrivals-departures is equal, the 50% will be assigned to departures and 50% to arrivals.

3. **Security controls:** To determine the number of x-ray machines needed, it is considered:

   - PHP(dep) $= 2000$ pax.
   - $b = 0$ $\rightarrow$ connecting pax not processed in airside.
   - $y = 600$ u/h $\rightarrow$ number of units that the machine is able to process in one hour.
   - $y = 2$ units $\rightarrow$ baggage items carried by passenger.

$$\boxed{\textbf{X-ray machine number} = \frac{PHP + b}{y}w = 6.666 \approx 7}$$

   A number of 7 x-ray machines are needed to give service to the airport.

4. **Health controls:** In the arrivals area, a health control is placed randomly for the passengers arriving from international flights. Considering:

   - $t = 0.17$ min $\rightarrow$ Average selecting process time.
   - $p = 400$ PAX $\rightarrow$ Number of PAX in the international critical aircraft (B777-300ER)
   - $m = 30$ min $\rightarrow$ required time to complete the control.

$$\boxed{\textbf{Number of positions} = \frac{p}{m}\Delta t \approx 3}$$

5. **Baggage claim area:** The dimensions of the baggage claim area, are compute according the following parameters.

   - PHP(arr) $= 2000 \rightarrow$ arriving passengers per hour.
   - $w = 30$ min $\rightarrow$ average time per passenger.
   - $s = 1.8\ \mathrm{m}^2 \rightarrow$ recommended area per passenger.

   $$\boxed{\textbf{Baggage claim area} = 1.1\frac{aws}{60} \approx 1000\ \mathrm{m}^2}$$

   To compute the number of baggage claim belts, it is considered:

   - $PHP = 1000 \rightarrow$ arriving passengers per hour.
   - $q = 0.7 \rightarrow$ proportion passengers in wide-body aircraft.
   - $r = 0.3 \rightarrow$ proportion passengers in narrow-body aicraft.
   - $y = 45$ min $\rightarrow$ average occupation time for wide-body aircraft.
   - $z = 30$ min $\rightarrow$ average occupation time for narrow-body aircraft.
   - $n = 400 \cdot 0.7$ min $\rightarrow$ number of pax in wide-body aircraft.
   - $m = 200 \cdot 0.3$ min $\rightarrow$ number of pax in narrow-body aircraft.

   $$\boxed{\textbf{Wide-body belts} = \frac{PHP_2 \cdot qy}{60n} \approx 4}$$

   $$\boxed{\textbf{Narrow-body belts} = \frac{PHP_2 \cdot rz}{60m} \approx 5}$$

   The total number of baggage claim belts is 6.

6. **Customs controls:** to determine the number of customs positions, the custom area needs to be defined.

   - $PHP = 2000 \rightarrow$ arriving passengers per hour.
   - $f = 0.8 \rightarrow$ proportion of inspected passengers.
   - $s = 1.5\ \mathrm{m}^2 \rightarrow$ area recommended per passenger.
   - $t = 2$ min $\rightarrow$ average passenger time.

   $$\boxed{\textbf{Number of customs positions} = \frac{PHP\Delta f}{60}1.1\Delta t \approx 59}$$

3 | Structural typology description

When it comes to building the terminal, it is important to specify which kind of materials are going to be used, and thus, the efforts that will hold the structure. In a general frame, it can be distinguished between two types of mechanisms of effort transmission to the foundation; firstly, the vertical efforts due to the gravitational load and, secondly, the lateral efforts due to the wind or possible earthquakes.

In the first case, the load-bearing elements work in compression and the ceilings work in bending-shear in the manner of a beam subjected to perpendicular loads in its plane.

In the second case, the same elements act differently. The ceilings receive and accumulate horizontal forces, working as a membrane and distributing forces between the different vertical elements, while the vertical elements work to bending-shear.

3.1 Foundation

Indonesia is a country with a very varied terrain due to the numerous geological faults combined with significant erosion. Volcanoes are the spine of Java. This irregular chain of volcanoes, which spread over the entire length of the island, forms the most active part of the 'Ring of Fire' volcano chain. The volcanism typical of Java's Island corresponds to the alkaline series, in which basalts, tephrites and phonolites predominate. Moreover, the zone is full of subterranean activity, earthquakes are fairly common. Most of them are not very powerful but it is very important to take into account this phenomena in terms of building the foundations.

The Island of Java is a region located in a area close to the coast, which implies the abundance of swampy land. Therefore, a deep foundation will be carried out in front of a medium or superficial one, since the superficial terrain will not be able to absorb the efforts that will transmit through a direct foundation.

Once selected the deep foundation method, it is proceed to define the geometry of the piles with which this foundation will be done. The piles to be used will be cylindrical and the relationship established between its height (H) and radius (R) in order to assure the consistency of the foundation is the following one:

$$\frac{Height}{Radius} > 15 \tag{3.1.1}$$

Usually, the height values of the piles will not exceed the 40 meters. From a conservative point of view, it has been selected a height of 35 meters and a base of radius 2.25 meters, which corresponds to a H/R factor of 15.55.

The last step to finish the foundation is to decide whether they are constructed with in situ piles or pre-fabricated ones. In the first case, piles in situ are better than the others in terms of acoustic pollution produced during its installation, but when it comes to low quality construction terrains it can not be the best solution. On the other hand, and therefore the remaining option, is the use of prefabricated piles, which are placed directly. The inconvenience is that this system requires the transport of the previously built piles to the site in which the foundation will be done. Moreover, it is important to take into account the very intense noise and vibrations this process will produce. Although the mechanism of intrusion of the piles by pressure is not suitable for all types of terrains, it is the appropriate method to build the foundations due to the characteristics of the region.

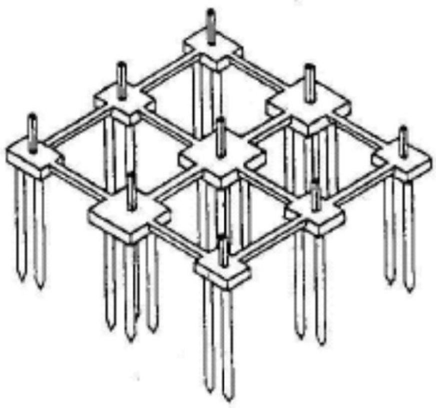


Figure 3.1.1: Schema of deep foundation with prefabricated piles.

3.2 Vertical elements

The pillars are the resistant elements responsible for supporting mainly compression loads in a vertical direction and also can absorb small lateral bending loads. The main function of them is to distribute the loads of the ceiling and the slabs to the foundation. It is important to remark that there is an alternative of vertical resistant elements, which are the loading walls but in case of Bekasi-East Jakarta Airport this solution will not be carried out.

The basic types of pillars found in construction are in situ reinforced concrete, prefabricated concrete, metal structure and mixed structure of steel and concrete. In the case of the new airport's terminal building, it is decided to make the pillars with mixed structure of steel and concrete. In this way, the pillars will have smaller sections than the those made of in situ reinforced concrete and will have more fire resistance than the metallic ones. Moreover, this type of pillars work very well in front of earthquakes, since the metallic armor is able to support the efforts in order to maintain the building up.

Starting from the foundation, the pillars of the ground floor will have a considerable section, since they will have to support greater loads and weight of the structure.

As far as the upper floor is concerned, some of the pillars from the ground floor will be extended to this level. At the level mentioned, it will not be necessary to place the same number of pillars as in the ground floor, since the structure in this case has to support less efforts and weight.

The distribution of the pillars can be seen in the drawings of the airport attached to the documents.

3.3 Slab

The slab is the horizontal structural element that directly receives the loads and transmits them to the remaining elements of the structure. Before deciding what type of slab will be used in the terminal building it is necessary to know the functions of it:

- Support itself and the loads received
- Support the construction process
- Solidarize all the elements of the plants
- Distribute the horizontal loads between all the elements
- Present compatibility of deformations with their functions
- Isolate the plants thermally and acoustically
- Resist to fire

It is also important to differentiate between types of slabs. It can be found unidirectional slabs, usually prefabricated or made of beams and vaults, and bidirectional, which can be waffle slabs or solid slabs.

Having a look to these different types of slabs, it is decided that the best option to the new airport terminal building will be a bidirectional waffle slab which will provide a bi-dimensional loads distribution. They are flat slabs without beams, composed of nerves in two directions, which can be built with recoverable moulds or with permanent lightening. The waffle slab must be filled with reinforced concrete and later framed. This process implies the need of approximately 28 days to be ready. The waffle frame allows to have higher lights than other ones and, in addition, there is no problem concerning its transportation, since it is built using in situ reinforced concrete.

Figure 3.3.1: Example of bidirectional waffle slab.

4 | Indoor flooring

4.1 flooring typology

Indoor flooring or paving is the horizontal base of a building (or the different bases of each building level). It works as a support for people or furniture. Indoor paving can be provided with several types of coating (wood, ceramics, marble, et cetera).

The coating material is the first thing to be decided before choosing any other feature of the floor, such as color, texture or specific details.

In general, the most common used materials in flooring are: wooden floors, ceramic floors, petrous floors and those made of concrete. There are also other materials, such as metallic and artificial composite floors, although these are less common.

Depending on the application that is going to be given to the floor, or the indoor zone in which is going to be set up, one must take into account the following aspects:

- **Wear and tear resistance**: it is advised to use ceramic floors, petrous or concrete. For example, in circulation areas or stairs.
- **Perforation resistance**: some concretes with specific resistances, some petrous or ceramic floors.
- **Humidity resistance**: ceramic, petrous and ceramic offer a high humidity resistance; on the other hand, wooden floors are not recommended. To be taken into account in restrooms or rainy areas.
- **Resistance to chemicals**: some kind of petrous floors such as granite and specific ceramics. In zones where chemical pourings can happen.
- **Hygiene**: the floor must have the ability of being easily cleanable and waterproof, to show an attractive and newflanged aspect.

To back up the decision that has been made, some general features of each floor type are presented next:

- **Wooden floors**: Nowadays, and thanks to the advanced wood treatments, it is possible to find dyed and varnished wooden floors. These kind of floors can last up to 50 years. They add warmness to cool places; and with a proper setting and maintenance they can remain as untouched during several years. Among their disadvantages, it is found that they require special care for cleaning and mantaining and also they can be deteriorated with humidity or water pouring. Wooden floors can be natural, synthetic or laminated. These floors are more common in Europe.

- **Ceramic stoneware or porcelain stoneware floors**: These kind of floors have a decent price according to its usage. The average lifetime of a stoneware tile is of about 30 years. Naturally, they have low resistance to wear due to material properties, although the can be restructured to increase resistance.

- **Petrous floors**: Different kind of stones are used in flooring: marble, slate, granite, quartz, sandstone, etc. Their main advantage is the wear resistance. This resistance is greater than for ceramic stoneware floors. Due to the attractive patterns and high resistivity properties, these materials can be the most expensive.

  Regarding marble pavings, this material denotes nobility and it was usually used for paving prestigious places. Its main features are its aspect and resistance; its disadvantages are the coldness to touch, and the necessity of a high maintenance to avoid imperfections.

  Other rocks used in paving are quartz, slate and granite, being the lattest much resistant than marble, but very expensive to cut, prepare and set into the floor.

- **Vinyl floors**: Vinyl floors are easy to clean, they also resist humidity and water pourings. They are easy to replace and to set above other floor coatings. This kind of floors are thermic and electrical insulators. Among their disadvantages, they look artificial and need a careful and correct use to avoid imperfections.

- **Smooth concrete floors**: This kind of floors are easy to maintain and offer resistance. Drawings, shapes and colors can be designed on it. A proper instalation leads not only to a good appearance but also to a greater resistance avoiding wear and fissures.

- **Brick floors**: Brick floors are economic, providing a rustic decoration or also common in exteriors, they offer a high sensitivity to attrition and show wear in heavily-transited areas.

- **Carpet floors**: They are quite economic and of easy instalation, without the need of hiring specialized personnel. Like wooden floors, carpet is available in different colors and patterns and provides warmness, and add aesthetics in the place used. It insulates sound and temperature. Its main disadvantage is the accumulation of dust, and therefore it requires a constant maintenance. Carpet floors are very common in the U.S., specially in public places such as airports.

4.2 Floor covering

In any paving, before setting the upper finishing layer, which is different depending upon the zone, it is important to know the layers that have to be included in-situ:

- Surface layer
- Grip layer
- Leveling layer
- No-grip intermediate layer
- Structural base

4.2.1 Structural base

The structural base is the layer that lies onto the floor. In the particular case of indoor paving, it is formed by a ground slab.

Ground slabs, also knowns as floor framings, are classified in terms of stability as a consequence of hydraulic retention, according to the normative UNE 22202-1.

The thickness of the ground slabs is determined by means of structual criteria, as functions of the CBR (California Bearing Ratio). On the other hand, a solicitation computation is also required.

4.2.2 No-grip intermediate layers

To enhance the floor properties different layers composed by different materials are inserted. These layers are the following ones:

- Waterproof layer: this layer raincoats the floor against liquid water. It is recommended to use a polyethylene layer of a minimum thickness of 2mm.
- Drainage layer: it helps removing the water that might be stored by means of a small slope.

- Acoustic insulation: there are specific layers for this function, and it helps insulate and reduce the impact of aerial noise, which is spread within the structure.
- Thermal insulation: it enchances a greater thermal resistance.

4.2.3 Leveling layer

These kind of layers are used to achieve the required flatness of the firm, and if a certain slope is required, they also provide this slope.

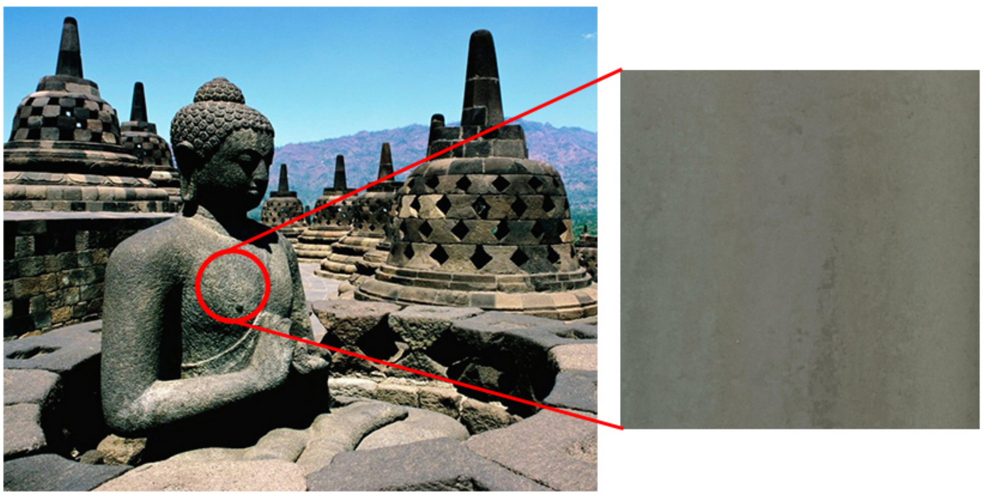
4.2.4 Grip layer

It consitutes the union between structural base and the tile or coating. It can be made of a leveling mortar or an adhesive. In the project, a leveling mortar has been chosen.

4.3 Design

The floor design and aesthetics is wanted to produce a homely and cozy feeling. In order to do so, it has been thought that it could fit with the tonalities of the landscapes that can be seen all across the country, and the beautiful sceneries that are spread along the islands and towns of Indonesia.

There is a lot of culture of esculptures in the islands of Java and Bali, for this reason, a floor design that reminds of the ancient sculptures of the country could fit in the airport and also provide a clean, elegant and cozy appearance.



On the other hand, an inspiration from the beautiful and relaxing beaches that the country offers, it has been chosen a floor that reminds of the sand that one can find in these beaches.

4.4 Superficial layer

4.4.1 Common areas flooring

In the common areas, it has been chosen to use a ceramic porcelain stoneware Floor Gres material, in particular the technical strong collection Chromtech/1.0 from the Floor Gres company, that is suitable for heavy traffic areas thanks to its high resistance. The color will be a neutral grey named cool/3.0 in the Floor Gres company color gamma.

Specification	Normative	Value
Water Absorption	ISO 10545-3	$< 0.1\%$
Breaking Strength	ISO 10545-4	> 1700 N
Scratch Hardness	ISO 10545-6	$< 150\text{mm}^3$
Thermal Shock Hardness	ISO 10545-9	Resistant
Chemical Resistance	ISO 10545-13	UA ULA UHA
Coefficient of Friction	DIN 51130	R10 (Matte)

Table 4.4.1: Technical Specs of Floor Gres Chromtech/1.0 floor.

The color chosen for our tiles within all the color shades is the one known as "Cool 3.0" with a matte and polished finishing.

Figure 4.4.1: Neutral gray color (Cool 3.0) from Floor Gres gamma.

The result of the floor chosen in the common areas is the following:

Figure 4.4.2: Result of instaling Chromtech/1.0 tiles in common areas.

4.4.2 Stairways and secondary areas flooring

Due to the high-end properties provided by the floor used in the common areas, it has been decided to use the same material but with a different tonality. In this case, the color chosen is a beige/taupe named Cool 1.0 in the Floor Gres color gamma. It is provided with a matte finishing.

The technical specs of these tiles are the same as for the tiles used in common materiales provided that the only change is the color. In general, this product provides an excellent finishing and it offers a high resistance. For this reason, it can be used in heavily-trafficked areas.

The color that has been chosen for stairways and secondary areas such as VIP lounges is the following:

Figure 4.4.3: Beige/taupe color (Cool 1.0) from Floor Gres gamma.

The result of the floor chosen in stairways and secondary areas is the following:

Figure 4.4.4: Result of instaling Chromtech/1.0 tiles in secondary areas.

4.4.3 Restrooms flooring

For the restrooms paving, it has been decided to use a rectified porcellanato tile, named "Portland Caliza" from the Spanish company Porcelanosa. These tiles are provided with anti-slip properties, making them exceptional for the usage in restrooms.

The color chosen is called "colored biscuit" and it is a neutral light gray:

Figure 4.4.5: Neutral light gray "Colored Biscuit" from Porcelanosa.

The result of instaling these tiles in the airport restrooms is the following:

Figure 4.4.6: Result of instaling Portland Caliza tiles in restrooms.

4.4.4 Offices flooring

The airport offices for ANSPs, customs and airlines are going to be provided with a porcelain stoneware tile called Basalike from a company called Panaria. The supply of these tiles is to be provided by the Italian company Sognando Casa, that manufactures several types of materials for indoor flooring.

These tiles offer an excellent natural finishing with an antislip index R10. The color chosen is a dark gray that inspires calmness and make the offices the perfect spot for working in any season of the year.

The color that will be instaled in the offices floor is the following:

Figure 4.4.7: Dark gray color in Basalike tiles from Panaria company.

The result of instaling these tiles in the airport offices is the following:

Figure 4.4.8: Result of instaling Basalike tiles in the airport offices.

These tiles have good quality and are optimum for an office flooring. In the next table, the technical specifications are shown:

Specification	Normative	Value
Water Absorption	ISO 10545-3	$< 0.5\%$
Breaking Strength	ISO 10545-4	> 1300 N
Scratch Hardness	ISO 10545-6	$< 175\text{mm}^3$
Chemical Resistance	ISO 10545-13	LA, HA
Coefficient of Friction	DIN 51130	R10 (Natural)

Table 4.4.2: Technical Specs of Panaria Basalike floor.

4.4.5 Automatic baggage handling system flooring

The automatic baggage handling system flooring is not so much sophisticated and for obvious reasons, ceramic or porcelanic tiles will not be used. In this area, polished concrete is to be used since it provides a set of good properties for this application:

- High surface mechanical resistance.
- Greater useful life than conventional concrete.
- High density and low porosity.
- Easiness of maintenance and cleaning.
- Low dust formation.

The supplying of the concrete and its respective polishing will be provided by the Spanish company EIROS, since it offers a good service at a honest price.

Figure 4.4.9: Result of instaling polished concret in the ABHS system (SATE).

5 Facade

5.1 Front and back facade

5.1.1 Requirements and adopted solution

5.1.2 Glass

5.1.3 Spider system with steel pillars

5.1.4 Steel and concrete mixed columns

5.2 Lateral facade

5.2.1 Facade (prefabricated concrete)

5.3 Other elements

5.3.1 Main door and other sliding doors

5.3.2 Access bridges

5.3.3 Emergency doors

5.3.4 Automatic baggage handling system doors

6 Building cover

6.1 Adopted solution

6.2 Shape and inclination of the building cover

6.3 Used materials

6.4 Sewer system

7 Indoor closures

7.1 Walls

7.2 Doors

7.2.1 Baggage claim hall doors

7.2.2 Office access and automatic baggage handling system access doors

8 | Fire prevention regulations

8.1 Fire prevention regulations and chosen materials

8.1.1 Building elements

8.1.2 Materials

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